

CLAIMS

What is claimed is:

1. A circuit for use in a phase-locked loop (PLL) comprising:

a phase detector comprising:

5 first and second input circuits to generate first and second PLL control
signals responsive to clock edges in first and second input signals,
respectively; and
a reset circuit to generate a reset signal based on said first and second
PLL control signals to reset said first and second input
10 circuits; and

a cycle slip detector for each one of said first and second input circuits, each said
cycle slip detector generating a slip indication signal based on said reset
signal, a corresponding one of said first and second input signals, and a
corresponding one of said first and second PLL control signals.

- 15 2. The circuit of claim 1 wherein each said cycle slip detector comprises slip
detection logic to generate said slip indication signal when a clock edge in said
corresponding one of said first and second input signals is received during said reset
signal.

- 20 3. The circuit of claim 2 wherein said slip detection logic comprises a delay element
to generate a delayed version of said reset signal, and wherein said slip detection logic
additionally generates said slip indication signal in response to receiving a clock edge in
said corresponding one of said first and second input signals when said delayed version
25 of said reset signal is asserted.

4. The circuit of claim 1 wherein each said cycle slip detector comprises slip detection logic to generate said slip indication signal when a clock edge in said corresponding one of said first and second input signals is received when said corresponding one of said first and second PLL control signals is asserted.

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5. The circuit of claim 2 wherein each said cycle slip detector comprises slip detection logic, said slip detection logic comprising:

an output flip-flop with a clock input coupled to said corresponding one of said first and second input signals; and

10 a logic gate with a first logic input coupled to said reset signal and a second logic input coupled to said corresponding one of said first and second PLL control signals, and with a logic output coupled to a data input of said output flip-flop, said logic gate operative to assert said logic output whenever at least one of said reset signal and said corresponding one of said first and second PLL control signals is asserted.

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6. The circuit of claim 5 wherein said slip detection logic further comprises a delay element coupled to said reset signal and operative to generate a delayed version of said reset signal, said logic gate including a third logic input coupled to said delay element to receive said delayed version of said reset signal and operative to assert said logic output whenever said delayed version of said reset signal is asserted.

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7. The circuit of claim 1 wherein each said first and second input circuits comprises a latching circuit generating a corresponding one of said first and second PLL control signals as a latched output signal responsive to a first clock edge in a corresponding one of said first and second input signals.

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8. The circuit of claim 7 wherein said latching circuit comprises a reset input coupled to said reset signal and operative to reset said latched output signal when said reset signal is asserted so that said latching circuit responds to a next clock edge in said
5 corresponding one of said first and second input signals.

9. The circuit of claim 7 wherein said latching circuit comprises an input flip-flop configured such that:

10 a data input of said input flip-flop is coupled to a fixed assertion signal;
a data output of said input flip-flop is coupled to an input of said reset circuit and
to an input of said slip detection logic in a corresponding one of said cycle
slip detectors;
a clock input of said input flip-flop is coupled to said corresponding one of said
first and second input signals; and
15 a reset input coupled to a reset signal output of said reset circuit.

10. The circuit of claim 1 wherein said reset circuit comprises:

20 a logic gate with first and second inputs coupled to first and second PLL control
signals from said first and second input circuits, and operative to assert
an output signal when both said first and second control signals are
asserted; and
a delay element to generate said reset signal a defined delay after assertion of
said output signal from said logic gate.

✓ 11. A phase-locked loop (PLL) comprising:

a phase detector to generate first and second PLL control signals based on a detected phase difference between respective clock edges in first and second input signals, said phase detector comprising:

5 first and second input circuits to generate first and second PLL control signals responsive to clock edges in first and second input signals, respectively; and

a reset circuit to generate a reset signal based on said first and second PLL control signals to reset said first and second input circuits; and

10 a control circuit to generate a control signal based on said first and second PLL control signals;

a controllable oscillator to generate an output signal at a frequency based on said control signal; and

15 a first cycle slip detector to generate a first cycle slip indicator signal when a clock edge in said first input signal occurs during said reset signal; and a second cycle slip detector to generate a second cycle slip indicator when a clock edge in said second input signal occurs during said reset signal;

20 wherein said first input signal is derived from a reference clock signal and said second input signal is derived from a frequency-controlled output of said PLL.

12. The PLL of claim 11 wherein said first and second cycle slip detectors each comprise slip detection logic, said slip detection logic comprising:

25 an output flip-flop with a clock input coupled to a corresponding one of said first and second input signals; and

5 a logic gate with a first logic input coupled to said reset signal and a second logic
input coupled to a corresponding one of said first and second PLL control
signals, and with a logic output coupled to a data input of said output flip-
flop, said logic gate operative to assert said logic output whenever at least
one of said reset signal and said corresponding one of said first and
second PLL control signals is asserted.

10 13. The PLL of claim 12 wherein said slip detection logic further comprises a delay
element coupled to said reset signal and operative to generate a delayed version of said
reset signal, said logic gate including a third logic input coupled to said delay element to
receive said delayed version of said reset signal and operative to assert said logic output
whenever said delayed version of said reset signal is asserted.

15 14. The PLL of claim 11 wherein each said first and second input circuits comprises
a latching circuit generating a corresponding one of said first and second PLL control
signals as a latched output signal responsive to a first clock edge in a corresponding one
of said first and second input signals.

20 15. The PLL of claim 14 wherein said latching circuit comprises a reset input coupled
to said reset signal and operative to reset said latched output signal when said reset
signal is asserted so that said latching circuit responds to a next clock edge in said
corresponding one of said first and second input signals.

16. The PLL of claim 14 wherein said latching circuit comprises an input flip-flop configured such that:

- a data input of said input flip-flop is coupled to a fixed assertion signal;
- a data output of said input flip-flop is coupled to an input of said reset circuit and
- 5 to an input of said slip detection logic in a corresponding one of said cycle slip detectors;
- a clock input of said input flip-flop is coupled to said corresponding one of said first and second input signals; and
- a reset input coupled to a reset signal output of said reset circuit.

For the reasons stated above, the court concludes that the claims are patentable.

17. A radio transceiver comprising:

a receiver to receive a remotely transmitted signal at a receive frequency;

a transmitter to generate a transmit signal at a carrier frequency; and

a frequency synthesizer to generate a first output signal bearing on said receive

5 frequency and a second output signal bearing on said carrier frequency, said

frequency synthesizer comprising:

a reference clock circuit to generate a reference clock signal; and

first and second phase-locked loops (PLLs) to generate said first and second

output signals, respectively, at least one of said first and second PLLs

10 comprising:

a phase detector to generate first and second PLL control signals based

on a detected phase difference between respective clock edges in

first and second input signals, said first input signal derived from said

reference clock signal and said second input signal derived from a

15 corresponding one of said first and second output signals from said

frequency synthesizer, said phase detector comprising:

first and second input circuits to generate first and second PLL

control signals responsive to clock edges in first and second

input signals, respectively; and

20 a reset circuit to generate a reset signal based on said first and

second PLL control signals to reset said first and second input

circuits; and

a control circuit to generate a control signal based on said first and

second PLL control signals;

a controllable oscillator to generate said corresponding one of said first
and second output signals at a frequency based on said control
signal; and
a first cycle slip detector to generate a first cycle slip indicator signal when
5 a clock edge in said first input signal occurs during said reset
signal; and
a second cycle slip detector to generate a second cycle slip indicator
when a clock edge in said second input signal occurs during said
reset signal.

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18. The radio transceiver of claim 17 wherein said first and second cycle slip
detectors each comprise slip detection logic, said slip detection logic generating a
corresponding one of said first and second cycle slip indicator signals when a clock edge
is received in a corresponding one of said first and second input signals while at least
15 one of said reset signal and a corresponding one of said first and second PLL control
signals is asserted.

19. A method of detecting cycle slip in a phase detector circuit, the method comprising:

operating said phase detector to generate first and second PLL control signals
based on latching respective first clock edges in first and second input
5 signals;

resetting said phase detector with a reset pulse after both said first clock edges
occur to make said phase detector responsive to next clock edges in said
first and second input signals;

generating a slip indicator signal in response to said next clock edge occurring in
10 at least one of said first and second input signals before said reset pulse,
and in response to any clock edge in at least one of said first and second
input signals occurring during said reset pulse.

20. The method of claim 19 wherein generating a slip indicator signal in response to
15 said next clock edge occurring in at least one of said first and second input signals
before said reset pulse, and in response to any clock edge in at least one of said first
and second input signals occurring during said reset pulse comprises:

generating a first cycle slip indicator signal if said next clock edge occurs in said
first input signal before said reset pulse, and if said any clock edge occurs
20 in said first input signal during said reset pulse; and

generating a second cycle slip indicator signal if said next clock edge occurs in
said second input signal before said reset pulse, and if said any clock
edge occurs in said second input signal during said reset pulse.

21. The method of claim 19 further comprising:

deriving a delayed reset pulse from said reset pulse;

detecting whether any clock edges occur in at least one of said first and second

5 input signals during said delayed reset pulse; and

generating said cycle slip indicator signal in response to said any clock edges

occurring during said delayed reset pulse.

22. The method of claim 19 further comprising determining whether a missed clock

10 edge is an up-cycle slip or a down-cycle slip based on determining whether said phase
detector misses a clock edge in said first input signal or in said second input signal,
respectively.

23. The method of claim 22 further comprising generating said cycle slip indicator

15 signal as an up-cycle slip indicator upon occurrence of said up-cycle slip and generating
said cycle slip indicator signal as a down-cycle slip indicator upon occurrence of said
down-cycle slip.

24. The method of claim 22 further comprising:

20 deriving a delayed reset pulse from said reset pulse;

detecting whether a clock edge occurs in said first input signal during said
delayed reset pulse;

generating said up-cycle slip indicator in response to said clock edge occurring in
said first input signal during said delayed reset pulse;

25 detecting whether a clock edge occurs in said second input signal during said
delayed reset pulse; and

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